UNIT-8 ATOMS AND NUCLEI

VERY SHORT ANSWER QUESTIONS (1 Mark)

1. Define atomic mass unit. Write its energy equivalent in MeV.
2. What was the drawback of Rutherford model of atom?
3. What are the number of electrons and neutrons in singly ionised $^{236}_{92}U$ atom?
4. Name the series of hydrogen spectrum which has least wavelength.

*5. Any two protons repel each other, then how is this possible for them to remain together in a nucleus.

6. Define radioactive decay constant.
7 You are given reaction : $_1H^2 + _1H^2 \rightarrow _2He^4 + 24$ MeV. What type of nuclear reaction is this?

8. After losing two electrons, to which particle does a helium atom get transformed into?

9. Write two important inferences drawn from Gieger-Marsden's α-particle scattering experiment.

10. What will be the ratio of the radii of the nuclei of mass number A_1 and A_2?

11. In nuclear reaction ${}_1^1H \rightarrow {}_0^1n + {}_Q^PX$ find P, Q and hence identify X.

12. Binding energies of neutron $\left({}_1^2H\right)$ and α-particle $({}_2He^4)$ are 1.25 MeV/nucleon and 7.2 MeV/nucleon respectively. Which nucleus is more stable?

13. α-particles are incident on a thin gold foil. For what angle of deviation will the number of deflected α-particles be minimum?

14. A and B are two isotopes having mass numbers 14 and 16 respectively. If the number of electrons in A is 7, then give the number of neutrons in B.

15. If the amount of a radioactive substance is increased four times then how many times will the number of atoms disintegrating per unit time be increased?

16 An electron jumps from fourth to first orbit in an atom. How many maximum number of spectral lines can be emitted by the atom?

17. Under what conditions of electronic transition will the emitted light be monochromatic?

18. Why does only a slow neutron (.03eV energy) cause the fission in the uranium nucleus and not the fast one?

19. Write the relation for distance of closest approach.

20. In Bohr's atomic model, the potential energy is negative and has a magnitude greater than the kinetic energy, what does this imply?
Ans. : The electron revolving is bound to the nucleus.

21. Name the physical quantity whose dlimensions are same as Planck's constant. **Ans. :** Angular momentum

22. Define ionisation potential.

23. The ionisation potential of helium atom is 24.6 V. How much energy will be required to ionise it? **Ans. :** 24.6 eV

24. What is the energy possessed by an electron whose principal quantum number is infinite?

25. Write the value of Rydberg constant? **Ans. :** $1.097 \times 10^7\ m^{-1}$

26. Name the spectral series of hydrogen atom which lie in *uv* region.
Ans. : Lyman Series

27. Name the series of hydrogen spectrum lying in the infra red region.

28. What is the order of velocity of electron in a hydrogen atom in ground state. **Ans. :** $10^6\ ms^{-1}$

29. Write a relation for Paschen series lines of hydrogen spectrum.

Ans. : $\bar{\nu} = R\left(\frac{1}{3^2} - \frac{1}{n^2}\right) n = 4, 5.....$

30. Arrange radioactive radiation in the increasing order of penetrating power.

31. Write a relation between average life and decay constant.

32. Write two units for activity of radioactive element and relate them with number of disintegration per second.

33. The half life of a radioactive element A is same as the mean life time of another radioactive element B. Initially, both have same number of atoms. B decay faster than A. Why?
Ans. : $T_A = \tau_B = 1.44\ T_B$ $\therefore$ $T_A > T_B$ $\therefore$ $\lambda_A < \lambda_B$. Therefore B decay faster than A.

34. Draw the graph showing the distribution of Kinetic energy of electrons emitted during β decay.

35. Compare radii of two nuclei of mass numbers 1 and 27 respectively
(**Ans. :** 1 : 3).

36 Define atomic mass unit.

37. Write the energy equivalent of MeV.

38. Which element has highest value of Binding Energy per nucleon.

39. Mention the range of mass number for which the Binding energy curve is almost horizontal.

40. What is the ratio of nuclear densities of the two nuclei having mass numbers in the ratio 1 : 4?

41. Write two important inferences drawn from Rutherford α particle scattering experiment.

42. Draw a graph of number of undecayed nuclei to the time, for a radioactive nuclei. NCERT pg. 447

43. Write an equation to represent α decay.

SHORT ANSWER QUESTIONS (2 Marks)

1. Define distance of the closest approach. An α-particle of kinetic energy 'K' is bombarded on a thin gold foil. The distance of the closet approach is 'r'. What will be the distance of closest approach for an α-particle of double the kinetic energy?
2. Show that nuclear density is independent of the mass number.
3. Which of the following radiations α, β and γ are :
   (i) similar to x-rays?
   (ii) easily absorbed by matter
   (iii) travel with greatest speed?
   (iv) similar to the nature of cathode rays?
4. Some scientist have predicted that a global nuclear war on earth would be followed by 'Nuclear winter'. What could cause nuclear winter?
5. If the total number ofneutrons and protons in a nuclear reaction is conserved how then is the energy absorbed or evolved in the reaction?
6. In the ground state of hydrogen atom orbital radius is 5.3×10^{-11} m. The atom is excited such that atomic radius becomes 21.2×10^{-11} m. What is the principal quantum number of the excited state of atom?
7. Calculate the percentage of any radioactive substance left undecayed after half of half life.
8. Why is the density of the nucleus more than that of atom?
9. The atom ${}_{8}O^{16}$ has 8 protons, 8 neutrons and 8 electrons while atom ${}_{4}Be^{8}$ has 4 proton, 4 neutrons and 4 electrons, yet the ratio of their atomic masses is not exactly 2. Why?

*10. What is the effect on neutron to proton ratio in a nucleus when β^- particle is emitted? Explain your answer with the help of a suitable nuclear reaction.

11. Why must heavy stable nucleus contain more neutrons than protons?

12. Show that the decay rate R of a sample of radio nuclide at some instant is related to the number of radio active nuclei N at the same instant by the expression $R = -N\lambda$.

13. What is a nuclear fusion reaction? Why is nuclear fusion difficult to carry out for peaceful purpose?

14. Write two characteristic features of nuclear forces which distinguish them from coulomb force.

15. Half life of certain radioactive nuclei is 3 days and its activity is 8 times the 'safe limit'. After how much time will the activity of the radioactive sample reach the 'safe limit'?

16. Derive $mvr = \frac{nh}{2\pi}$ using de Broglie equation.

17. Draw graph of number of scattered particles to scattering angle in Ratherford's experiment.

18. Show that nuclear density is same for all the nuclei.

19. What is the shortest wavelength present in the (i) Paschen series (ii) Balmer series of spectral lines?
Ans. : 820nm, (ii) 365 nm

20. The radius of the inner most electron orbit of a hydrogen atom 0.53 Å. What are the radii of the $n = 2$ and $n = 3$ orbits.

21. The ground state energy of hydrogen atom is −13.6 eV. What are the Kinetic and potential energies of the electron in this state?

22. Write formula of frequency to represent (i) Lyman series (ii) Balmer series.

23. From the relation $R = R_0 A^{1/3}$ where R_0 is a constant and A is the mass number of a nucleus, show that nuclear matter density is nearly constant.

Ans. : Nuclear matter density $= \frac{\text{Mass of nucleus}}{\text{Volume of nucleus}}$

$$= \frac{mA}{\frac{4}{3}\pi R^3} = \frac{mA}{\frac{4}{3}\pi R_0^3 A}$$

$$= \frac{m}{\frac{4}{3}\pi R_0^3} \approx 2.3 \times 10^{17} kg / m^3$$

= Constant

24. Find the energy equivalent of one atomic mass unit in joules and then in MeV.

Ans. : $E = \Delta mc^2$ $\Delta m = 1.6605 \times 10^{-27}$ kg

$= 1.6605 \times 10^{-27} \times (3 \times 10^8)^2$

$= 1.4924 \times 10^{-4}\ J$

$= \frac{1.4924 \times 10^{-10}}{1.6 \times 10^{-19}}\ eV$

$= 0.9315 \times 10^9$ eV

= 931.5 MeV

25. Write four properties of nuclear force.

SHORT ANSWER QUESTIONS (3 Marks)

*1. Give one example of a nuclear reaction. Also define the Q-value of the reaction. What does Q > 0 signify?

2. Explain how radio-active nucleus can-emit β-particles even though nuclei do not contain these particles. Hence explain why the mass number of radioactive nuclide does not change during β-decay.

3. Define the term half life period and decay constant. Derive the relation between these terms.

4. State the law of radioactive decay. Deduce the relation $N = N_0 e^{-\lambda t}$, where symbols have their usual meaning.

5. Give the properties of α-particles, β-particles and γ-rays.

6. With the help of one example, explain how the neutron to proton ratio changes during alpha decay of a nucleus.

7. Distinguish between nuclear fusion and fission. Give an example of each.

8. A radioactive isotope decays in the following sequence

$$A \xrightarrow{\alpha} A_1 \xrightarrow{\pi} A_2.$$

If the mass and atomic numbers of A_2 are 171 and 76 respectively, find mass and atomic number of A and A_1. Which of the three elements are isobars?

9. Obtain a relation for total energy of the electron in terms of orbital radius. Show that total energy is negative of K.E. and half of potential energy.

$$E = -\frac{e^2}{8\pi E_0 r}$$

10. Draw energy level diagram for hydrogen atom and show the various line spectra originating due to transition between energy levels.

11. The total energy of an electron in the first excited state of the hydrogen atom is about –3.4 eV. What is

    (a) the kinetic energy,

    (b) the potential energy of the electron?

    (c) Which of the answers above would change if the choice of the zero of potential energy in changed to (i) + 0.5 eV (ii) –0.5 eV.

Ans.

(a) When P.E. is chosen to be zero at infinity E = – 3.4 eV, using E = – K.E., the K.E. = + 3.4 eV.

(b) Since P.E. = – 2E, PE = – 6.8 eV.

(c) If the zero of P.E. is chosen differently, K.E. does not change. The P.E. and T.E. of the state, however would alter if a different zero of the P.E. is chosen.

(i) When P.E. at ∞ is + 0.5 eV, P.E. of first excited state will be –3.4 – 0.5 = – 3.9 eV.

(iii) When P.E. at ∞ is + 0.5 eV, P.E. of first excited state will be –3.4 – (–0.5) = –2.9 eV.

12. What is beta decay? Write an equation to represent β^- and β^+ decay. Explain the energy distribution curve is β decay.

13. Using energy level diagram show emission γ rays by $^{60}_{27}Co$ nucleus and subsequent β decay to obtain $^{60}_{28}Ni$. NCERT pg. 457

LONG ANSWER QUESTIONS (5 Marks)

1. State Bohr's postulates. Using these postulates, drive an expression for total energy of an electron in the n orbit of an atom. What does negative of this energy signify?

2. Define binding energy of a nucleus. Draw a curve between mass number and average binding energy per nucleon. On the basis of this curve, explain fusion and fission reactions.

3. State the law of radioactive disintegration. Hence define disintegration constant and half life period. Establish relation between them.

4. What is meant by nuclear fission and nuclear chain reaction? Outline the conditions necessary for nuclear chain reaction.

5. Briefly explain Rutherford's experiment for scattering of α particle with the help of a diagram. Write the conclusion made and draw the model suggested.

6. State law of radioactive decay obtain relation

   (i) $N = N_0\, e^{-\lambda t}$

   (ii) $R = R_0\, e^{-\lambda t}$

   where N is number of radioactive nuclei at time t and

   N_0 is number of radioactive nuclei at time t_0 λ is decay constant

   R is rate of decay at any instant t

   R_0 is rate of decay at any time t_0 (initial time).